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Elisha Mitchell Scientific Society

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Elisha Mitchell Scientific Society

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PROCEEDINGS OF THE ELISHA MITCHELL SCIENTIFIC SOCIETY, JANUARY 1907 TO OCTOBER 1907.

169TH MEETING, JANUARY 15, 1907.

H. V. Wilson: The Regenerative Power of Sponges.

J. W. Gore: Direct Current Transmission of Power.
The Electrical Aging of Flour.

170TH MEETING, FEBRUARY 12, 1907.

J. H. Pratt: The Fish and Oyster Industries in North Carolina.

Collier Cobb: Some Human Habitations.

171ST MEETING, MARCH 19, 1907.

J. E. Latta: Some Recent Developments in Electric Traction.

N. C. Curtis: Architectural Composition.

172ND MEETING, APRIL 16, 1907.

Archibald Henderson: The Foundations of Geometry.

Chas. H. Herty: The Optical Rotation of Turpentines.

At the close of the program a business meeting was held to consider the programs. It was voted that a minimum of four meetings be held each year but, if possible, one meeting per month.

BUSINESS MEETING, SEPTEMBER 23, 1907.

A business meeting was held in the chemical laboratory with Pres. Herty in the chair. The following officers were elected for the ensuing year:

President: W. C. Coker.
Vice-President: J. E. Latta.
Permanent Secretary: F. P. Venable.
Recording Secretary: A. S. Wheeler.
Editorial Committee:

W. C. Coker, Chairman.
A. Henderson.
E. V. Howell.

A. S. WHEELER, Recording Secretary.

A NEW METHOD BY WHICH SPONGES MAY BE ARTIFICIALLY REARED.[1]

DR. H. V. WILSON

I have found in the course of an investigation carried on for the Bureau of Fisheries that silicious sponges when kept in confinement under proper conditions degenerate, giving rise to small masses of undifferentiated tissue which in their turn are able to grow and differentiate into perfect sponges. The investigation has been prosecuted during the past three summers at the Beaufort Laboratory. While the degeneration with the formation of the indifferent masses has been observed in several species, it is only in one species, a *Stylotella*, that the process as a whole has been worked out.

This sponge, which is exceedingly abundant in Beaufort Harbor, is a fleshy monactinellid commonly reaching a thickness and height of 10–12 cm. Conical processes with terminal oscula project upwards from the lower body. With this species, which is a light-loving form, I have obtained the best results when outside aquaria, either concrete aquaria or tubs, were used. The method of treatment is briefly this: Into a tub about 60 cm. by 30 cm. and covered with glass, a half dozen sponges, freed as far as possible from live oysters and crabs, are put. They are raised from the bottom on bricks. The tub is emptied, filled and flushed for some minutes three times in every twenty-four hours. Direct rays of the

[1]Published with the permission of Hon. Geo. M. Bowers, U. S. Commisioner of Fisheries.

Reprinted from SCIENCE, N. S., Vol. XXV., No. 649, Pages 912-915, June 7, 1907,

sun should be avoided. Tubs answer as well as concrete aquaria, and have the advantage of being movable.

In a day or two the oscula of the sponge disappear, and the surface begins to acquire a peculiar smooth, dense and uniform appearance. Microscopic study reveals the fact that not only the oscula, but the pores also, for the most part close, and the canal system becomes interrupted and in some degree suppressed. The mesenchyme is more uniform, and is denser than in the normal sponge, owing in part at least to the disappearance of the extensive collenchymatous (very watery mesenchyme) tracts of the latter.

The whole sponge may pass into this state and remain without great change for weeks. During this period it shrinks greatly in size, in a given case to one quarter the original bulk. The arrangement of the skeletal spicules becomes much simplified. With the shrinkage in size the sponge becomes more solid, *i. e.*, more of the canal space is suppressed. Some flagellated chambers persist and there are a few small scattered apertures on the surface. The bulk of the chambers disappear as such, the collar-cells transforming into simple polyhedral masses which become scattered singly or in groups in the general mesenchyme. The mesenchyme is a syncytium composed of well-marked cells that are freely interconnected. The sponge in this condition closely resembles *Spongilla* in its winter phase, as described by Weltner.[2] Presumably water continues to circulate through the body, but the current must be an exceedingly feeble and irregular one.

As a sponge in this condition continues to shrink, it may subdivide and thus a large sponge may eventually be represented by numerous masses, in a given case about 1 cm. in diameter. Now if the sponge in this condition or if one of the masses into which it has split up, be attached to wire gauze and suspended in a live box floating at the surface of the open water of the harbor, the sponge or piece will in a few days grow and redevelop the pores and oscula, flagellated chambers, tissue differentiation, and skeletal arrangement of

2 'Spongillidenstudien, II. Archiv fur Naturgeschichte,' 1893.

the normal sponge. Whether in this regeneration the transformed and separated collar cells again unite to form the flagellated chambers, I can not say. I think it very doubtful.

In the two classes of cases just described the sponge as a whole degenerates and slowly shrinks. Cellular death takes place so gradually that at no time is there any obvious corpse tissue or skeletal debris. Much more common and of far greater interest are the following cases. In these a large part of the sponge body dies in the course of two or three weeks, leaving the skeletal network still in place and bearing the brown decaying remnants of the flesh, which, as maceration continues, are washed away. In places, however, the sponge body does not die. Here masses of living tissue are left, conspicuous amidst the dead remains by their bright color and smooth clean surface. These living fragments may be classified into three groups. First, the upper end of an ascending lobe or a considerable part of the body of the lobe may be left alive in its entirety, thus forming a more or less cylindrical mass up to 5 mm. diameter, with a length sometimes two or three times the thickness. The histological condition of these masses is not very different from that of the sponges already described. Such a mass may be said to consist of anastomosing trabeculæ, separated by the remains of the canal system. The mesenchyme composing the trabeculæ consists of discrete cells interconnected by processes to form a synctium. The flagellated chambers as such have nearly disappeared, although remnants may still be recognized. In them the collar cells have transformed into simple polyhedral bodies that are widely separated. The bulk of the chambers have broken up into their constituent cells, and these are now scattered as elementary parts of the general mesenchyme. When such masses are attached to wire gauze and hung in a floating live-box they transform into perfect sponges.

A second class of surviving remnants includes masses scattered over the general surface of the sponge. These may be spheroidal and small, less than one millimeter in diameter. Usually they are flattened and of an irregular shape with

lobes, suggesting a lobose rhizopod or myxomycete plasmodium. Such masses which may be connected by slender strands are commonly from two to five millimeters in the longest direction. The third class of remnants are found scattered through the body of the dead and macerated sponge, in which they sometimes occupy positions that are obviously favorable for respiration. These bodies are more or less spheroidal and small, their diameter varying commonly from one half to one and a half millimeters. In the most successful cases of treatment, the small masses, internal and superficial, are exceedingly abundant, and the dead and macerated sponge body with its contained nodules of conspicuous living tissue strongly suggests a *Spongilla* full of gemmules.

These living remnants of the sponge (bodies of the second and third classes) execute slow amœboid changes of shape and position, behaving thus like plasmodia, and they may be designated as plasmodial masses. Microscopic examination shows them to be of an exceedingly simple character. without canal spaces or flagellated chambers. The mass does not consist of discrete cells, but is an aggregation of syncytial protoplasm studded with nuclei. The protoplasm is stored with minute inclusions and is reticulate in arrangement. The nuclei are practically all alike, and there are no signs of persisting collar-cells. Such a mass represents a portion of the original sponge in which the degenerative changes have progressed farther than in the larger remnants. In the latter we find a syncytium made up of discrete cells among which some persisting collar-cells are distinguishable. But in the plasmodial mass the cells have united so intimately that cell outlines have been wiped out, and recognizable collar-cells (or their nuclei) have disappeared. The optical evidence points to the conclusion that the latter help to form the general syncytium, undergoing regressive changes in their differentiation which result in their becoming indifferent parts of this unspecialized tissue.

The plasmodial masses remain alive in the laboratory indefinitely, but do not transform. They attach to the bottom

of the vessel, but so feebly as to be easily shaken loose. In order to see if they would transform when returned to natural conditions, I devised the simple plan of enclosing them in fine bolting-cloth bags which were hung in a live-box floating in the harbor. The bags, rectangular, were divided into compartments about an inch square with the two flat sides nearly touching. In each space an isolated plasmodial mass was inserted, and the bag sewed up. It was found that in such bags the masses were held in place long enough for them firmly to attach to the bolting cloth. Once attached to the cloth they grow, sometimes quite through the wall of the bag to the outer water, and transform into perfect sponges with osculum, canals, pores and flagellated chambers in such abundance as to be crowded.

This ability to undergo—when the environment is unfavorable but not excessively so, regressive changes of differentiation resulting in the production of a simpler, more uniform tissue, is something that is plainly useful, *i. e.*, adaptive. In the simplified state the sponge protoplasm withstands conditions fatal to such parts of the body as do not succeed in passing into this state, and on the return of normal conditions again develops the characteristic structure and habits of the species. That this power is exercised in nature there can scarcely be a doubt, since the conditions that are present in an aquarium must now and then occur in tidepools.

It is probable that the power thus to degenerate with the production of masses of regenerative tissue is general among sponges. I first discovered the phenomenon in *Microciona*, a very different form from *Stylotella* and one in which the skeleton includes much horny matter. And in two other Beaufort species I have succeeded in producing the plasmodial masses. There is every reason for believing that the commercial sponge shares in this ability. If this is so, we have here a means of propagation which with a further development of methods may at some time become economically practicable. In any case it is now possible to study the differentiation of a quite unspecialized tissue, one that is physi-

ologically embryonic, into a perfect sponge at any time of the year irrespective of the breeding season. We may even exercise some direct control over the size of the plasmodial masses, as the following experiment shows.

Microciona was kept in aquaria until the degenerative process had begun. Pieces were then teased with needles in a watch glass of sea water in such a way as to liberate quantities of cells and small irregular cell-agglomerates. These were gently forced with pipette to the center of the watch glass. Fusion of cells and masses, with amœboid phenomena, began at once, and in half an hour quite large irregular masses existed. In the course of a few hours the masses grew enormously through continued fusion. From this time on they adhered firmly to the glass, retaining irregular plasmodium-like shapes, and the growth was inconspicuous. To bring them together once more and induce further fusion they were on the following day forcibly freed, with pipette and needle, and to clean them of cellular débris and bacteria were transferred to a tumbler (covering with bolting cloth) in which they were kept actively moving under a fine glass faucet for about thirty minutes. In the course of this violent agitation a good many masses were lost. Those remaining in the tumbler became in the next few hours noticeably rounder and smoother at the surface. From this experiment eighteen more or less spheroidal masses were obtained, some of which measured one half millimeter in diameter. They were similar to the small plasmodial masses produced in this species (and in *Stolotella*) when the sponges are allowed to remain quietly in aquaria. As already stated, it is only in *Stylotella* that I have directly proved the regenerative power of these masses.

Maas has just announced[3] that calcareous sponges (*Sycons*) when exposed to sea water deprived of its calcium undergo

3 'Ueber die Einwirkung karbonatfreier und kalkfreier Salzlösungen auf erwachsene Kalkschwämme und auf Entwicklungsstadien derselben. Archiv fur Entwicklungsmechanik der Organismen,' Bd. XXII., Heft 4, December, 1906.

marked degenerative changes, which may be of such a character that the living tissue quite separates from the skeleton and breaks up into compact cords of cells showing active amœboid phenomena. The cords further constrict into rounded masses the likeness of which to gemmules is pointed out. Maas states that he is not yet in a position to say whether these masses have the power to transform into sponges, but adds that some of his observations induce him to believe that this is possible.

It is evident that Maas, working on very different forms, has independently met with the same degenerative-regenerative phenomena as are described in this communication, the essential facts of which were presented (together with an exhibit of gemmule-like degeneration masses and young sponges into which such masses had transformed) at the recent December meeting of the American Society of Zoologists. I may add that more than two years ago at the end of the summer of 1904, in my official report (unpublished since the research was still in progress) to the Bureau of Fisheries on the investigation under my charge, I described the degenerative phenomena in *Microciona* and *Stylotella*, *i. e.*, the formation under certain conditions of confinement of minute masses presenting a likeness to gemules, and emphasized the probability that these masses were able to regenerate the sponge. It was not, however, until the summer of 1906 that I was able to demonstrate the truth of this view.

UNIVERSITY OF NORTH CAROLINA.
CHAPEL HILL, N. C.,
February 16, 1907.

THE CONDENSATION OF CHLORAL WITH PRIMARY AROMATIC AMINES. II.*

BY ALVIN S. WHEELER.

A number of condensation products of chloral with primary aromatic amines have already been described. The first mention of such a reaction is probably that of Maumené[1] who hoped to obtain indigotine by the action of chloral (2 mols.) upon aniline (3 mols.). His product was a brownish black uncrystallizable substance containing no chlorine. Schiff and Amato[2] first describe a condensation product of chloral (1 mol.) and aniline (2 mols.) with the formula

$$CCl_3CH(NHC_6H_5)_2.$$

In the same year Wallach[3] describes this compound. Later[4] he gives a full description of the products obtained from aniline, p-toluidine, and a sample of xylidine boiling at 212°-216°. Eibner[5] studied the condensation of chloral with p-nitraniline, m-chloraniline, p-chloraniline, and 1, 2, 4-dichloraniline and showed that 1, 2, 4, 6-trichloraniline and 2, 6-di-

*Contribution from the Chemical Laboratory of the University of North Carolina.

1[Ber. 3. 246, (1870)].

2[Gazz. chim. ital. 1,376 (1871)].

3(Ber. 4. 668).

4(Ann. 173,274).

5(Ann. 302,235).

chlor-4-nitraniline do not react. Wheeler and Weller[6] prepared the o- and m-nitraniline compounds and Wheeler and Daniels[7] showed that only addition products could be obtained with the naphthylamines. Niementowski and Orzechowski[8] found that one molecule of chloral condensed with one molecule of anthranilic acid but later[9] obtained the expected diphenamine compound. Finally Rügheimer[10] describes the compounds with o- and p-phenylenediamine and 1, 2, 4- and 1, 3, 4-toluylenediamine. He also states that only addition products are obtained with the naphthylamines.

The chloral diphenamine compounds vary considerably in stability. Most of them may be kept for years. They possess great crystallizing power. Their behavior toward alkalies is variable. The aniline derivative is decomposed by alcoholic potash into aniline, chloroform and phenyl cyanide according to Wallach. The p-nitraniline derivative is converted by alcoholic potash into an hydroxy compound, one chlorine being replaced by the hydroxyl group according to Wheeler and Glenn[1]. They are not stable in the presence of strong mineral acids. These split the compound so as to reform the amine. Eibner has shown that boiling acetic anhydride and benzoyl chloride give the acetyl or benzoyl derivative of the original amine. I have found that all of them react with great readiness with bromine in the cold. There is a substitution of one hydrogen atom in those which have been analyzed. This substitution probably occurs in the methylene group of the chloral residue.

With the exception of the anathranilic acid products the following are thought to be new.

[6](Jr. Am. Chem. Soc. 24, 1063).

[7](Jr. Elisha Mitchell Sci. Soc. 22, 90 (1906).

[8](Ber. 28, 2812).

[9](Ber. 35, 3898).

[10](Ber. 39, 1653).

[1](Jr. Elisha Mitchell Sci. Soc. 19, 63, 1903).

CHLORAL AND p-BROMANILINE.

Trichlorethylidenedi-p-bromphenamine,

$$CCl_3CH(NHBrC_6H_4)_2.$$

With C. W. Miller. Ten grams of p-bromaniline were dissolved in 50cc benzene and 8 grams of chloral (4.2 grams required by theory) in 10cc benzene were added. The mixture was concentrated one-half on the water bath and cooled. A white flocculent precipitate came down. This gave a melting point of 135°. On further evaporation a second crop was obtained, showing a melting point of 119°. By several recrystallizations from benzene the melting point was raised to 140°. The yield of the crude product was quantitative.

Analysis:

0.1588g substance gave 0.2049g CO_2 and 0.0352g H_2O.
0.1638g substance gave 9cc nitrogen at 15° and 755mm.
0.0890 substance heated with 0.3274g $AgNO_3$ required 9.8cc NH_4SCN (1cc = 0.0173g $AgNO_3$).

	Calculated for $C_{14}H_{11}N_2Cl_3Br_2$	Found
Carbon	35.45	35.03
Hydrogen	2.34	2.46
Nitrogen	5.93	6.38
Chlorine + bromine	56.24	55.58

Trichlorethylidenedi-p-bromphenamine consists of fine colorless needles, melting at 140° and decomposing at 205°. It is extremely soluble in alcohol, acetone, glacial acetic acid and hot benzene. It is sparingly soluble in cold benzene and insoluble in ligroin. It is readily purified by using a mixture of benzene and ligroin. It is not decomposed by boiling water but is split by boiling concentrated hydrochloric acid with the regeneration of p-bromaniline. A bromo derivative is easily obtained by adding bromine to a glacial acetic acid solution. The product, consisting of plates, melts at 203°

after several recrystallizations from glacial acetic acid. Determinations of carbon, hydrogen and nitrogen give very satisfactory figures for a monobrom compound. A study of its constitution is under way. Chlorine gives a similar reaction. The product, crystallizing in long colorless needles, melts at 93° after recrystallization from glacial acetic acid. Analysis indicates a monochlor derivative. These bodies will be described in a later paper.

CHLORAL AND O-ANISIDINE.

Trichlorethylidenedi-o-methoxyphenamine,

$$CCl_3CH(NHOCH_3C_6H_4)_2.$$

With W. S. Dickson. Two molecules (12.3g) of o-anisidine were dissolved in 50cc benzene and one molecule (7.3g) of chloral were added. After warming a short time on the steam bath a separation of colorless needles occurred. These decomposed at about 215° and weighed 0.05g. On concentration of the filtrate in a dessicator a mass of fern-like crystals was obtained mixed with a thick liquid. After filtering the crystals were pressed on a porous tile. The product was white, melted at 112°-114° and weighed 9.7 grams. On recrystallizing from benzene the melting point was raised to 121°. The thick liquid finally solidified, considerably increasing the yield.

Analysis:

0.2000 gram substance gave 0.2294 gram AgCl.

1.0000 gram substance gave 0.073 gram nitrogen (Kjeldahl).

	Calculated for $C_{16}H_{17}O_2N_2Cl_3$	Found
Cl	28.35	28.35
N	7.47	7.30

Trichlorethylidenedi-o-methoxyphenamine crystallizes from ligroin or benzene in magnificent rhombohedra, from one

quarter to one half inch long, always with a slight yellow color. It is easily soluble in cold benzene and carbon tetrachloride and hot glacial acetic acid. It is slightly soluble in cold ligroin and fairly soluble in hot ligroin. It crystallizes from alcohol in long slender prisms. One hundred cubic centimeters of boiling alcohol will dissolve approximately 7 grams and at 25° about 2.5 grams. It is insoluble in and unchanged by boiling water. When boiled in concentrated hydrochloric acid the odor of chloral could be detected in the vapors. A bromo derivative is readily obtained by adding bromine to a concentrated glacial acetic acid solution. The crystals occur in clusters of needles and decompose at about 230°. This compound is being further investigated.

CHLORAL AND p-ANISIDINE.

Trichlorethylidenedi-p-methoxyphenamine,

$$CCl_3CH(NHOCH_3C_6H_4)_2.$$

To a solution of 12.3 grams p-anisidine in 20cc benzene (a nearly saturated solution) is added 7.3 grams chloral. The solution turns to a dark red color at once, much heat is developed and a deposition of 0.22 gram small colorless crystals occurs. These decompose at about 215° as in the case with o-anisidine. After filtering, the reaction mixture is boiled 15 minutes and then allowed to stand several hours. An abundant crystalline precipitate is formed. After filtering and pressing on a clay plate, the product melted at 115° and weighed 10.5 grams. A further yield was obtained from the mother liquor. Purification was effected by using the mixed solvent, benzene and ligroin. The melting point was raised to 118°-120°.

Analysis:

0.2087 gram substance gave 0.2398 gram AgCl.

	Calculated for $C_{16}H_{17}O_2N_2Cl_3$	Found
Cl	25.35	28.41

The para compound crystallizes from ligroin in brilliant scales, showing a strong pink color in the mass. It melts at 118°-120° and decomposes at 158°. It is fairly soluble in cold benzene, alcohol and ether. It is readily soluble in glacial acetic acid, hot benzene and hot alcohol. The hot alcohol solution emits a most disagreeable odor and on spontaneous evaporation to dryness a jet black crystalline mass remains. It is very slightly soluble in cold ligroin and not readily in hot ligroin. On treatment with bromine in glacial acetic acid solution a crystalline product is obtained which blackens at about 198°. This compound will be studied further.

CHLORAL AND ANTHRANILIC ACID.

The product obtained in this case depends upon the proportions used. One molecule of chloral will condense with one or two molecules of anthranilic acid with the elimination of one molecule of water. The two products have been described by Niementowski but his method yields a mixture and we have improved upon it since we wish to make the compounds in quantity in order to study their bromo derivatives.

Trichlorethylidene-o-aminobenzoic Acid,

$$CCl_3CHNC_6H_4COOH.$$

With W. S. Dickson. Five grams of anthranilic acid were dissolved in 40cc boiling benzene (a saturated solution) and 5.5 grams chloral in 10cc benzene were added. The weights are in the proportion of one molecule to one molecule. The mixture was boiled under a reflux condenser for three hours, filtered from a small precipitate and then cooled. A crystalline deposit, weighing 5.0 grams and melting at 148°-151°, separated. The crystals were large elongated tables, occurring in clusters. From the filtrate was obtained 3.0 grams of material, melting at 145°-150°. Several recrystallizations from benzene raised the melting point to 152°. Niementow-

ski and Orzechowski[1] prepare this compound without the use of any solvent. They use an excess of chloral and get several by-products. We have tried their method but have employed theoretical proportions. Even so we get the same by-products. We set the mortar in a block of ice and rapidly stirred together the previously cooled substances. The mixture liquefied and then rapidly became very hard. This product decomposed at about 127°, after two hours on ice at 124° and after three hours more at room temperature at 118°. It was rubbed up with a little water and filtered. The decomposition point rose to 135°. Now taking advantage of the marked difference in solubility in benzene of the mono- and di-compounds (not observed by Niementowski) we extracted the crystalline mass, weighing 8.2 grams, with 45cc boiling benzene. From the extract there separated a mass of colorless needles, weighing 3.7 grams and melting 149°-152°, hence nearly pure mono-compound. On evaporating the filtrate a residue was obtained, weighing 1.3 grams and melting at 160°, a good quality of the di-compound. A second extraction was made with 33cc of boiling benzene. On cooling this yielded a product weighing 0.8 gram and melting at 162°, and a residue at 157°. There still remained an insoluble residue, dark purple in color. These results are in marked contrast to those obtained by our method of boiling in benzene, for we get practically only the mono-compound and consequently a much larger yield.

Analysis:

0.2000 gram substance gave 0.3189 gram AgCl.

	Calculated for $C_9H_6O_2NCl_3$	Found
Cl	39.92	39.43

On treating a glacial acetic acid solution of this compound with bromine a bromo derivative is obtained in large quantity. On cooling a hot glacial acetic acid solution it deposits

[1](Ber. 28, 2812).

in clusters of fern-like crystals which decompose at 237°. This body is under investigation.

Trichlorethylidenedi-o-aminobenzoic Acid,

$$CCl_3CH(NHC_6H_4COOH)_2.$$

Five grams (2 molecules) anthranilic acid in 40cc boiling benzene were treated with 2.9 grams (1 molecule) chloral in 10cc benzene and boiled under a reflux condenser for three hours. During the boiling there separated 3.25 grams of the di-compound, melting at 164°-165°. On cooling a further yield of 0.6 gram was obtained. On evaporation to dryness the residue was found to weigh 4.0 grams and to melt at 157°. The pure body melts at 165°. The method of Niementowski[1] was tried and although found to be better than for the preparation of the mono-compound it gave a smaller yield than our method and a larger amount of unknown colored by-products.

Analysis:

0.5000 gram substance gave 0.0410 gram NH_3 (Kjeldahl).
0.2000 gram substance gave 0.2113 gram AgCl.

	Calculated for $C_{16}H_{13}O_4N_2Cl_3$	Found
N	6.96	6.76
Cl	26.11	26.10

The di-compound consists of a crystalline powder and may be purified by precipitating its ether solution with ligroin. Upon boiling eight hours with acetic anhydride and cooling, a crystalline substance deposits, melting at 183° and crystallizing from benzene in needles. This corresponds to acetyl-o-aminobenzoic acid. On treating a glacial acetic acid solution with bromine there is almost instantly obtained a heavy precipitate which after recrystallization from glacial acetic acid melts with decomposition at 236°. This behavior is surprisingly like that of the bromo derivative of the mono-anthranilic acid compound.

[1](Ber. 35, 3898).

CHLORAL AND O-TOLUIDINE

Trichlorethylidenedi-o-tolamine,

$$CCl_3CH(NHC_6H_4CH_3)_2.$$

With Strowd Jordan. Chloral and o-toluidine were brought directly together in the proportion of one molecule to two molecules. No advantage was found in using benzene as a solvent. 19.3 grams chloral were added to 28 grams of o-toluidine, the mixture turned dark red and the temperature rose to 80°. After standing for some time, often over night, a quite hard crystalline cake formed. This was dissolved up in ether or successively extracted with benzene. In either case, a small residue weighing 0.7 gram remained. This was pale greenish in color and melted at 213°. The main product of the reaction was recrystallized from ether until the melting point reached 80°.

The yield was 70 per cent of the theory.

Analysis:

0.1763 gram substance gave 0.2194 gram AgCl.
0.2000 gram substance required 0.2915 gram $AgNO_3$.
0.2000 gram substance required 0.2973 gram $AgNO_3$.

	Calculated for $C_{16}H_{17}N_2Cl_3$	Found		
Cl	30.95	30.77	30.40	30.96.

The Stepanow method[1] was employed in the second and third analyses and found to be extremely convenient. With some of our compounds we have found it impracticable on account of the deep color of the solution. We found it advisable to adopt the suggestion of Rosanoff and Hill[2] and filter off the silver chloride before titrating.

Trichlorethylidenedi-o-tolamine crystallizes in very long silky needles. It is not very stable in solution or when ex-

[1](Ber. 39. 4056).

[2](Jr. Am. Chem. Soc., 29, 269).

posed to the light. It is decomposed by water into chloral and o-toluidine. It is soluble in cold alcohol, ether, acetone, chloroform, carbon tetrachloride, carbon disulphide and glacial acetic acid. It is soluble in hot ligroin, benzene and methyl alcohol. The pure substance melts at 80° and will melt repeatedly at that temperature. A bromo derivative is readily obtained in glacial acetic acid solution. It forms silvery white plates which melt with decomposition in the neighborhood of 268°.

PHYSIOLOGICAL ACTION.

We were led to a study of the physiological action of the trichlorethylidenedi-o-tolamine by an accidental observation. Mr. Jordan unintentionally got a small quantity in his mouth and within a few hours there followed a marked physiological action. A preliminary test has been made upon two rabbits. Dr. William DeB. MacNider of this University kindly carried out the test for us in the pharmacological laboratory of the University of Chicago. A 5 per cent dilute alcoholic solution was employed. This was first used in 10cc doses, intravenously. It produced at first a slow heart action accompanied by a slight fall in blood pressure. Following this initial change the respirations became accelerated, the heart action fast and the fall in blood pressure much more pronounced. Doses of 25cc given by the stomach caused the animal to become drowsy, inactive and imperfectly responsive to stimuli. The respirations were accelerated. One rabbit returned to a normal condition in six hours. The other animal, receiving the drug by the stomach, died apparently from respiratory failure. A more complete study is under way upon a large number of rabbits. This study will be extended to other diphenamine derivatives of chloral.

Chapel Hill, N. C.
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RECENT CHANGES IN GOLD MINING IN NORTH CAROLINA THAT HAVE FAVORABLY AFFECTED THIS INDUSTRY

BY JOSEPH HYDE PRATT AND A. A. STEEL.*

Before taking up an account of the changes that have been recently introduced in gold mining in North Carolina, it may be of interest to mention some of the causes for failure in the profitable mining of gold in this State, as the changes to be described hav to some extent at least modified and lessened the chances for failure.

Many of the causes of failure in North Carolina gold mining can be traced to a lack of adequate capital, which prevents mining from being conducted in the most economic manner. One of the most noticeable of these is the tendency to sink the shafts but 15 to 30 feet before driving a new level and then stoping out a small block of ground instead of having the levels from 75 to 100 feet apart. Since a ton of ore removed in driving the level even in a wide vein will cost fully twice as much as a ton of ore in stoping, it is obviously more economical to have as few levels as possible. It it becomes dificult to make the raises more than 100 feet and is expensive to get men and timbers into much higher stopes. Therefore, the levels should not be over 100 feet apart. In a narrow vein where much waste could be left in a stope, the economy is greater. Somewhat similar to this is the habit of sinking a number of shafts close together instead of only one or two on a vein. This is not so bad for working ore

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near the surface, but becomes very expensive as the mine gets deeper, especially when hoisting machinery is required on each shaft. This is partially explained by the fact that many of the old mines have been worked at very irregular intervals and the old shafts have become caved in during the period of idleness.

Even those mines having capital are often badly managed. They frequently put in machinery of unnecessarily large capacity, not realizing that a very small engine and bucket can easily get out 10 or 15 tons of ore per day and keep a five stamp mill busy. There are many little mines that could pay a profit under careful management with five stamps and running only one shift; but some of them have engines big enough to hoist four times as much ore. Since the engineer and top men must be there all the time, there is no economy in operation but may even be a loss, since the engine cannot work steadily and fuel is wasted keeping up a big fire; and' of course, the first cost is greater. If the mine ever gets much too big for the small engine, it can be used in prospecting or underground work.

A great many shafts are much to big. It is not uncommon to see a little bucket, 30 inches accross dangling in the middle of a hoisting compartment 6 feet square in the clear, It is considerably cheaper to sink a shaft with compartments only 4 feet square in the clear and when the hoisting compartment is smoothly lined with plank (to assist ventilation), or fitted with guides, it has jnst as great a capacity — usually more than enough for the output of the mine. If necessary, the hoisting capacity of a shaft may be greatly increased at any time by putting in a tall bucket, or better a self-dumping skip and high speed engine. The ladder and pipe compartment is often as big as 6 by 8 feet. Since the cheaper and better direct acting steam pump would now be placed in a shaft, instead of the clumsy and bulky Cornish pump, the water, steam and compresed air pipes take up very little room. It is now customary to put in slanting ladders between landings some distance apart. They can almost as well be a little

steeper and shorter and go in a smaller space. The men will always ride up in a bucket, fitted with a crosshead running in proper guides or running in a closely planked compartment if the shaft is crooked. Therefore, the ladderway is an emergency exit only and a good, continuous vertical ladder securely fastened against one wall of the compartment is all that is needed, and the compartment for ladder and pipes may seldom need be over 3 by 4 feet. The two compartments and the division between them then need be only 4 by8 or 3½ by 7 feet inside. Besides being much more cheaply and rapidly sunk, the small shaft need not be so heavily timbered, since the shorter timbers are stronger and the earth pressure tends to arch around the shaft instead of coming fnll upon the timbers. On the other hand, the first 6 by 10 feet (8½ by 12½ feet outside timbers) shaft at the Montgomery Mine, at Candor, Montgomery County, became useless after about 5 years from the buckling of the timbers, although splendidly timbered with 12 by 12 inch oak sets, which showed no signs of decay.

There is, of course, very seldom any need for more than one hoisting compartment, since the saving in power will only pay for the greater expense of engine and shaft when a large amount of ore is to be hoisted from considerable depth. When a single large skip will handle all the ore, there is no need of putting in another to remain idle half the time.

Timber framing for shafts and tuunel sets is often unnecessarily complicated and the carpenter must waste mnch time chiselling, when simple notches laid off with a square and cut by saws are often stronger and always more easily made.

The most disastrous error is usually great haste in putting in a mill or smelter. It seems that the first thing that many miners think of after finding a little good ore is to stop work in the mine and put in a mill; so there are mills which have been able to run less then a month before the mine was exhausted. There is usually a neighboring mill to which thə ore might as well have been hauled. It is seldom that tests are made to tell what sort of a mill and treatment is adapted

to the ore. Unless the ore body is large, no mill should be installed until the changed ore below the water level has been tested.

In North Carolina there seem to be only a few miners who deceive themselves by assaying the rich streak and assuming that the entire streak will be equally as good. The general principles of sampling the entire body seem to be well understood, although it is not always done as accurately as it should be.

Even when good ore occurs in paying quantities the miner frequently builds a mill that is too large; For there is only a little extra expense in increasing the size of the mill after it has been running awhile instead of building a large mill all at once. So there is little excuse for assuming the greater risk of a large mill. There is less loss of gold in adjusting a small mill.

One agreeable exception to the practice of building a mill before the mine is sufficienty developed is seen in the work of the Whitney Company, who have carefully tested and explored a number of mines. Many of the options were given up of course. At the old McMakin Mine at Gold Hill, as explorations proved the value of the mine, the contemplated scale of working was gradually increased. When the small shafts of the upper levels were deepened, the lower parts were made large enough for balanced hoisting and the small part will be enlarged later. In the meantime most careful sampling and assaying was done and when enough ore had been blockedout, careful mill tests were made chiefly upon the material obtained from drifts. In this way a total of 4,950 tons of ore was run through the little mill on the ground; careful records of everything gave an average recovery of $4.52 of gold on the plates and only $0.34 per ton as a concentrate worth but $5.03 per ton and $0.83 per ton in the tailings. These tests made clear that the most economical method is simple amalgamation, giving a saving of about 80 per cent of the gold, with no attempt to concentrate and treat the concentrates.

The two main shafts are down 800 feet and another is 400 feet deep, with the levels averaging over 700 feet long. This work shows a vein averaging 14 feet wide and gives a million and a half tons of ore blocked out ready to stope, and which will yield $2.50 per ton by amalgamation. They have accordingly planned a mill large enough to treat 1,000 tons of ore per day, making the estimated total cost of mining, milling and transporting the ore only $1.48 per ton. They are now waiting for the completion of their water-power plant before building the mill and since they have sufficient ore blocked out, the mine has been idle and full of water since the spring of 1905. The intention is to keep a reserve of 500,000 tons of ore in advance of the stoping.

The Bonnie Doone, or Old Smart Mine, has also been properly developed by Mr. J. C. Bates, a former owner of the Howie Mine. The old 80 foot shaft has been deepened to 200 feet, with levels 125 feet long at 60 feet, 100 feet at 120 feet, 160 feet at 186 feet. The ore obtained from these workings is now piled in a large dump estimated to contain 3,000 tons. And before the mill was planned, this was carefully sampled by a competent mining engineer, who dug deep trenches across it and found it to average $15.00 per ton. Of course a great deal of the same quality of ore has been blocked out in the mine. There are about 500 tons in another dump of material which came from work in the walls and is chiefly slate but contains a few of the veinlets and masses of milky quartz, and is said to assay about $1.50 per ton. It has been kept out of the good ore at only a nominal expense. The mill has not been built on account of the continued sickness of the owner, so there is no machinery at the mine except the sufficiently large prospecting hoist.

As an example of a mill too large for the development may be mentioned the Reimer Mine, near Salisbury. Here a 20 stamp mill with chlorination failed simply because no ore at all had been blocked out and it could not be mined rapidly enough to keep the mill going. An examination of the mine by the late Mr. Parker, mining engineer for the Whitney

Company, showed a remarkably continuous vein, averaging 3½ feet wide and carrying $7.50 in gold.

Mr. Parker planned to develop the mine so that it might easily yield 50 tons per day, so the total cost of mining and treating the ore would be about $4.50 per ton, which includes depreciation, etc.

The general custom of having no reserves of ore blocked out prevents conservative mining men from investing in them, since there is no way of determining the value of the vein unless it is opened up. It would be much better to spend the cost of a premature mill in developing ore so that there would be no difficulty in securing capital or selling the mine to advantage.

It is also quite customary to extract all of the ore by underhand stoping. This becomes very expensive when the vein is so narrow that some of the wall-rock must be broken to make room, or when the vein contains much barren rock. All of this waste material must then be hoisted to the surface and much of it becomes mixed with the ore in the bins and chutes. If the stopes are mined upward or overhand, all the waste can be left in them supported on a single line of stulls over the drift. This often affords a scaffold for the men and so saves the great expense of putting in many stulls. In addition a large block of filling will serve as a pillar to hold the walls apart so no ore need be left in the mine. One excellent mine superintendent said that the reason for this was the fact that most of the miners are more properly farmers and cannot drill holes upwards. They do not work steadily enough to warrant an attempt to teach them how, even though skilled men prefer to drill "uppers." This objection can be overcome in those mines having air drills for driving levels by installing a few of the blockholing or air hammer drills which may be held in one hand and, besides being much quicker, can be worked in stopes too narrow for hammering by hand. So far there seems to be none of these machines in North Carolina, although they are becoming standard in the west.

When the mines yield rich ore in narrow streaks, it should be hand-picked before going to the mill. For this purpose the Miami Mining Company have installed at the Phoenix Mine, near Concord, Cabarrus County, an ore picker. The ore is sorted into coarse and medium material by passing through a trommel, where it is also washed by a spray pipe. It then passes over a couple of belts 30 inches wide and 30 feet long. A number of boys sit along these belts and pick out the waste, which is removed by another belt, while the good ore passes direct to a Dodge crusher. The dirt and fine ore removed by the water is raised by a sand pump directly to the battery. These machines would not pay at a small mine where an arrangement like that at the Hercules Mine at Cid, Davidson County, is better. Here the ore is dumped from the skip on to a slightly elevated platform, where it is washed by a stream of water from a hose and the waste thrown into a car standing near, as the good ore is shovelled into a car for taking it to the mill.

Since the publication of Bulletins Nos. 3 and 10 of the North Carolina Geological Survey, there have been a number of changes in mining practiced in the State, which, given in the order of their probable importance, are:

1. The application of machines of the old log washer type to separate gold from saprolites as is now being practiced at the Shuford, Empire, Beaver Dam, Troy, Sawyer and other mines.

2. The introduction of square set timbering in the extraction of soft, deep ore bodies, which is now being practiced at the Union Copper Mine at Gold Hill.

3. The introduction of the cyanide process for treating certain sulphuret ores, which has been practiced on the tailings trom the Iola, Montgomery and Howie mines.

4. The introduction of self-dumping skips, picking belts etc.

LOG WASHERS

Perhaps the most important change to be noted in gold mining practice in North Carolina is the introduction of log washers in treating many of the saprolitic ores that are found quite abundantly throughout many portions of the State. The old principle of the log washer cannot be patented, but the machines that are now being used, known as modern pulverizing concentrating machines, possess many mechanical improvements that adapted them to the work that they are called upon to do.

Each separate unit of these machines consists of two improved log washers running at high enough speed to readily disintegrate the soft material and so mix the clay into a fine pulp with water that the gold can readily settle to the bottom. Each machine is essentially a long trough or boiler plate containing a revolving cylinder fitted with heavy white iron arms set spirally so that the ore, while being hammered fine, is gradually worked to the discharge end. At the end of the first washer, the larger, hard and nearly barren quartz stones are removed by a revolving screen and belt conveyor, this being done to save wear and power in the second washer, where the gravel is still further reduced iu size and more gold settles out. The gravel that remains after passing the second washer is removed by a finer screen and the chief pulp, free from stones, passes from the riffled sluices about three feet wide and of varying lengths, which contains mercury to amalgamate and save any free gold that does not settle in the machine.

The steel troughs are about 2 feet wide by 2½ feet deep, the first being 18 feet long and the second 12 feet, with a semicircular bottom and a flat wood top. The revolving cylinder is made of an 8-inch steam pipe carried upon a heavy steel shaft, passing through stuffing boxes at the ends of the trough. Wrought iron bars reach through this pipe crosswise and project about 3 inches on each side to form legs to which 8½ inch cast iron arms are bolted to take all the wear. There is about 4 inch clearance between these arms and the

bottom of the troughs, which allows the formation of a bed of stones, which reduces the wear on the bottom and helps save the gold. This bed of stones is of course more or less shaken up by blows from the large fragments of quartz and by the revolving arms, thus permitting the gold to settle through as in panning. The constant striking of the paddles against the surface of the water will also weight and sink some of the float gold. The discharge end of the machine is set 6 inches higher than the feed end so that the gold, once down amongst the pebbles of the bed, is not apt to be pushed out.

Riffles of the sluices are made by boring inclined auger holes in the planks laid lengthwise in the cement-lined sluice boxes. Since all the coarse gravel has been screened out, there is little wear upon the riffles and the fall and quantity of water are less than in the regular sluice for hydraulic mining. In cleaning up, the planks are lifted up and turned over and the gravel and mercury washed to the end of the sluice where quicksilver and amalgam are washed out in hand pans. When through cleaning up, the planks are simply replaced and the riffles filled with mercury and the machine started again.

In cleaning the washers, which is usually done twice a week the machines are stopped and all the gravel within washed out with a hose through an opening in the bottom. This gravel is then panned by hand and the gold amalgamated. Any nuggets that occur in the rock are pounded free from quartz and are then also amalgamated.

The amalgam from all sources is strained out of the quicksilver and then retorted and the bullion sold.

The chief wear on the machine is the arms, which under certain conditions, as on the sharp ore at the Shuford mine, only last six weeks. They can, however, be readily made at any foundry.

It is recommended by the maker that the first washer be driven at 150 to 250 revolutions per minute and that the second one at 250 to 350 per minute and that for a capacity of 10 tons

per hour, each machine be given 72 gallons of water per minute. This will then at times require 25 H P. for a complete unit of two washers and trommels. These factors will vary greatly with the character of the ore. Since the power, and therefore the wear, will increase even more rapidly than the square of the speed, this should be kept low. In the absence of any coarse stones, there is also danger that the pulp may be too greatly agitated to allow the settling of the gold. On the other hand, the speed and work must be sufficient to grind up the ore. If there is too little water, the clay paste may not allow the gold to settle. If there is too much, there is a danger of the gold being washed out. While a large capacity is of advantage and desirable, still it will mean danger of insufficient grinding, too thick pulping, or too strong a flowing of water. A great deal of skill and patience is, therefore, required in adjusting these fixtures, but when once adjusted, they will work satisfactorily. It is to be recommended that a first unit be installed and run over several months at various speeds, capacities and amounts of water and the machine should be given plenty of time after each change of condition to adjust itself. Also, careful tests of the ore and tailings should be made between times. The capacity and speed should first be adjusted until the best result is given in reducing the amount of gold left in the tailings so combined that it will not pan. The pulp should of course be kept at a reasonable consistency throughout the changes and the amount of water finally adjusted so that the tailings will show a minimum of free gold in the pan.

These machines are made in Knoxville, Tenn., and are handled by Geo. L. Erdman, of Asheville, N. C. One of the first of these machines was installed at the Shuford Mine, owned by the Catawba Gold Mining Company, and situated about three-quarters of a mile north of the post-office of Edith, about 5 miles south-east of Catawba Station on the Southern Railway. They have a plant of 4 double units. The Company are operating on a tract of land containing a gold-bearing zone said to be 2 miles long and 600 feet wide.

This will all pan gold at the surface and has been tested by bored holes 30 to 50 feet deep to water level and by one old shaft 115 feet deep. This zone is filled with small quartz seams from a line to occasionally several inches thick and having all possible strikes and dips and seldom more than two feet apart in every direction. The country rock varies from schist to gneiss and is generally heavily stained by iron oxide and thoroughly decomposed, except for a few, bold outcropping hard masses. The quartz is usually thoroughly honey-combed and broken into soft, angular fragments. Except at the surface, most of the gold is in these quartz streaks, but the hard and solid portions of them seldom have much value. At the present time the entire mass is being mined by means of an irregular pit which was, in the summer of 1906, 90 feet deep and 250 to 300 feet across at the top. The material at the bottom is just as soft and decomposed as at the top and the ore is loosed by black powder and shovelled by hand into cars containing a cubic yard. The cars are hoisted up a steep incline and automatically dumped over a grizzly of light steel rails. The fines are washed through the grizzly by jets of water, the soft large lumps being crushed and knocked through by means of a pick. In 18 months operation only a few tons of large, hard lumps have thus far been thrown out. The material is then washed down a trough about 50 feet long, thus becoming pretty uniformly mixed before being divided among the washers. At this mine the machines are run at only 150 revolutions per minute. They were tried at a lower speed, but there was trouble with the gold sticking to clay balls. The machine used about 150 gallons of water to the minute and the whole plant is run by a 35 horsepower engine which, when the three units are running, is probably overloaded. The tailings, when tested, usually pan nothing at all, but assay a few cents, due to gold included in the sand. While this loss could be reduced by speeding up the second washer to grind the sand finer and trusting to the riffles to save what little additional free gold would not then settle in the machine, it

is doubtful whether with the present small plant and so vast a quantity of ore controlled by the Company such refinements are advisable, since they would probably reduce the capacity of the plant. It is estimated that the present cost of treatment is 22 cents per cubic yard loose measure with a recovery of between 50 cents and $1.00 per cubic yard.

A great deal of the success of the Catawba Gold Mining Company is due to its conservative policy and the skill with which the whole mining and milling operation has been conducted.

The next machine to be placed in operation was at the old Laflin Mine, near Cox, Randolph County, about 4 miles east of Cid Station on the Thompsonville and Glen Anna Railway. The Empire Mining Company own a tract of land which contains argillaceous slates containing two gold-bearing zones, 200 feet wide by ½ mile long, the northwest zone being along the south side of a hard quartz and siliceous slate vein. The early work on this property was done at the northeast end of the northwest zone where there are several large pits, some 50 feet deep. The entire surface was tested by pan assays (weighing the amount of gold from known weighed amounts of ore) and a number of trenches were dug across the better portions of the zone. The results of this test led the Company to instal their experimental plant on the gentle slope to another stream near the southwest end of the northwest zone. At the other end the slates are still soft at a depth of 50 feet, but here they were found to be quite solid and tough within 6 or 7 feet of the surface, though drill holes are said to have proved that the rock is again soft below a 5 or 6 foot shell of hard material. The dip at this end is only 15 or 20 degrees instead of being nearly vertical as at the other. This tough slate is thoroughly oxidized and shows a very uniform distribution of wheat-like grains of limonite, formed from pyrite, which lie along the cleavage planes of the slate and all the gold occurs in them.

This small branch has a steep fall for 2 miles to the Yadkin River and for the experimental plant water is returned

from a small settling pond nearby. In order to get sufficient fall for the head and tail sluices, the machines are put pretty high up on the hill so that a fat incline has been put in with dumping arrangements, etc. similarly as at the Shuford Mine. The ore is broken up by hand into about 3 inch cubes and when not hard, there is some tendency for it to stick in the grizzly crusher owing to the large percentage of clay, which is often moist. The first machine is run as high as 250 revolutions per minute on hard rock, but was found to give best results on average partly decomposed slates at 175 revolutions per minute. As there is no hard quartz in this ore, there is no need of an intermediate trommel. The second machine is operated at only 90 revolutions per minute and saves most of the gold, which is very fine. The trommel which follows this washer removes practically nothing but fragments of tree roots, which shows that everything is ground below 4-mesh. The riffles are 64 feet long, but very little gold is found below the first 20 feet. With this soft, clayey ore the capacity is about 8 tons per hour and 110 gallons of water per minute are required. In the summer of 1906 the machine had hardly passed the experimental stage, but the tailings almost never showed any free gold and assays of carefully taken samples showed a recovery of 90 per cent of the soft material and 80 per cent on the hard.

A few modifications of the machine have been made by Mr. O. K. McCutcheon, Superintendent of the Empire Company, by introducing an improved stuffing box and valve for the clean-up openings and in the second washer iustalling a plate 9 inches wide and one inch above the center of the bottom with cross-lots ½ inch by 5 inches. This false bottom is curled up at the discharge end and serves as a riffle plate, thus considerably increasing the recovery of very fine gold.

One double unit of these machines was being worked on the property of the Troy Mining Co., 7 miles north of Troy, Montgomery County. There are some old shafts, but the two main workings are based upon recent discoveries. By test pits and panning it seems there are two parallel zones of

slate bearing gold. Open cut No. 1 shows white and pink, clay-like slates with iron stains and abundant limonite cubes and seams. The direction of the slates is N. 45° E. and part of the material seems to represent thoroughly decomposed, sheeted, coarse grained porphyry so that the deposit is probably on a contact. The values are not uniform and at a depth of about 12 ft. the deposit seems to be about 20 ft. wide, 50 ft. long and the upper part of a rounded lens, richest in the center, where a 25 ft. shaft is said to have produced $30.00 ore. To develop deeper, a shaft was sunk in the hanging wall. At a depth of 70 feet, it was stopped just as it began to cut light-colored, sericitic schists, carrying pyrite.

The material from open cut No. 1 was all conveyed by a sluice to the mill, a short distance away. Although a good deal of gold was saved, the tailings ran $3.00 a ton and tests were stopped.

Open cut No. 2 was made by recent unsuccessful hydraulic mining. It was, at the time of the visit, 200 feet long, 20 to 24 feet wide and 2 to 10 feet deep. This zone pans quite uniformly 18 to 20 feet wide in the cut and in cross trenches beyond the end of it. No assays of average samples have been made. There is a barren, white quartz vein, with some large quartz crystals, along part of one side of the zone and most of the material seems to have been more or less siliceous sericite schist, now thoroughly decomposed to purple clay or fine sand. At the time of the visit, 100 tons were being hauled over muddy roads to the mill about a quarter of a mile away, to make a test run.

The machines were found to give a little less free gold in the tailings as the speed was reduced, and at the time of the visit, both sections were being run at only 60 R.P.M. The rate of feeding is very low, apparently only 2 tons per hour, and the amount of water is very large, apparently about 150 gallons per minute. As there was no hard pebbles or other material in the ore to form a bed in the machine, it is probable that most of the gold was washed out. Even at this low rate of speed the coarsest tailings were very fine

particles of sand. Samples of the tailings included only the coarser, rapidly settling parts, so that the assays made were probably too high. It may be that the slower speed simply decreases the pan assay of the tailings by not freeing such a large percentage of gold which remains included in the larger grains.

The most apparent recommendation would be to put McCutcheon riffles in the bottom of the machine, run the first machine faster than the second and greatly increase the percentage of ore fed to machine as compared with the amount of water used. No samples of the ore had been taken so the tests are not conclusive.

The latest reports are that the tailings from open cut No. 2 also assayed $3.00 to $4.00 per ton; that the washers are abandoned and that a 50 ton cyanide mill will be erected. It is also said that some good ore was struck below a quartz vein in a 17 ft. shaft, sunk in open cut No. 2. It is probably well to abandon the washers here because the thoroughly decomposed soil gets very hard not far from the surface, and the water level will be less than 30 feet below the highest part of the ore zone now exposed. Therefore the available tonnage of decomposed material is rather small. A shaft on a third vein, just below the creek bed, shows hard silicified sericite slates, with much pyrites but no visible copper or other minerals which would interfere with the cyanide plant adapted for handling slimes.

Machines have also been installed at the old Sawyer Mine in Randolph County 5 miles west of Sophia and about 14 miles from High Point. This property has been worked off and on for many years, but has failed because the gold could not be saved by a stamp mill and plates. The machine will first treat the soil and very soft outcrops and then the hard rock, which does not slack by itself will be crushed fine by rolls and the machine used simply as a panning device. This will be a new and novel use for this machine and the results will be watched with interest.

The McCutcheon modification of the Modern Pulverizing and Concentrating machine is being installed at the old Mer-

rill Mine on Carraway Creek 3 miles west of Sophia. The old workings are said to show a zone 1-2 mile long which is composed principally of clay to a depth of 50 or 60 feet. There are eight long cross-cut trenches and many test pits have been made which are said to have given ore running from $1.50 to $1.90 per ton.

Near Newton, Catawba County, one of the machines is being installed to work a property said to be similar to the Shuford Mine in the same county.

From information obtained by observation in the field and tests in the laboratory, it would seem that this Modern Pulverizing and Concentrating machine is adapted for certain ores such as those of the Shuford Mine and that with certain modifications as have been worked out by Mr. McCutcheon, the machine can be adapted to still other ores. It is necessary, however, to make a careful study of the ore and to adjust the machine to each particular ore before it can be determined whether or not the machine will save the gold; and a machine should not be accepted or discarded until the ore has been thoroughly tested to ascertain whether or not the machine can be adapted to that particular ore.

SQUARE SETS.

The second change in mining practice of great importance to the gold mining industry in North Carolina is the introduction of square set timbering in the extraction of soft deep ore bodies. This method was introduced by Mr. H. L. Griswold, superintendent of the Union Copper Company's mine at Gold Hill, N. C. In former mining the old stopes were held open by miscellaneous timbering such as stulls, lock sets and truss sets. Such methods were not satisfactory and prevented the stoping of the ore in the most economical manner. By the introduction of the western square set method of timbering, the stoping of the ore is being done safely, completely and economically. The sets are made of 8 x 8 inch sawed oak and the mine carpenter can usually easily frame enough timber for this work in about one-eighth of his time. The

sets are 6 ft. 3 inches high in the clear and 5 feet across in the clear. The posts are, therefore, 6 ft. 3 inches long between the shoulders and have a 5 x 5 inch tenon 1½ inches long at each end; the caps are 5 ft. 3 inches between shoulders and have a 5x5 inch tenon 2½ inches long at each end; the ties are 5 feet between shoulders and have a tenon 5x8 inches and 1½ inches long at each end.

The size of the timbers will of course vary with the weight to be sustained. This style and proportions of framing are very good for oak timbers; but for pine, which crushes so easily across the grain, it is better to have the ends of the post tenons to touch each other. The light timbers are of course cheaper and much more easily handled. As the stopes get large, they are more or less completely filled with waste rock which is usually obtained in mining and would otherwise have to be hoisted out in working the usually underhand stopes. This filling also holds the posts in position and helps to prevent them from buckling or "jack-knifing" if any one timber yields, which might otherwise endanger the whole system. Since most of the pressure is downward, as soon as the ore is blasted away to make room for a new set, all the sets below are relieved and tend to come back to their original position. Thus, even light timbers will hold very well if the stope is worked rapidly enough.

In the Union Copper mine the square sets were founded upon a platform built upon the old solid looking truss sets. As soon as a heavy load came upon them the trusses buckled sidewise and everything caved in. A new foundation was then made upon reinforced stulls and there has been no trouble since. Mr. Griswold is starting a new lot of square sets in a large open chamber just above the fourth level and he will thus be able to work out easily all the ore left above, especially a big pillar that remains between the first and second levels.

A new set can be added in any position at any time without disturbing the adjoining timbers and the old timbers can easily be supported by temporary props while making room

for an additional set. When the old timbers have been replaced the entire flooring of sets is easily put in as the ore is removed; a temporary plank covering may be placed across the old timbers to protect the men from falling rocks. Temporary plank floors are placed upon the sets for the men to stand upon and, as the system becomes higher, chutes and mill holes are put in to conduct the ore to the car on the track below. Any waste rock mined is merely dumped in and around the lower sets.

There has been little or no trouble indtroducing the square set method of timbering and at the Union Copper Mine the work is done under the immediate supervision of Mr. Hedrick, a skilfull North Carolina shift boss who has had no previous experience with square sets. Some of the miners, especially negroes, when first stoping by means of square set timbering are a little nervous because they are so close to the roof that they can see how loose the rocks are; but they soon realize that they can pick down the loose rock or prop it up and, therefore, are safer than when they are so far away that they cannot tell at what moment the rock may fall upon them. Also when working at the bottom of a high, underhand stope, a blow from even a small rock would be dangerous.

CYANIDE PLANTS.

The introduction of the cyanide process for treating certain sulphuret ores is a third change in mining practice in the State that has added considerable to the production of gold. One of the most successful cyanide plants was the one erected to work the tailings of the Howie mine, near Waxhaw, Union County. This mine is in a zone of hard, siliceous slates, carrying chimney-like bodies of pretty high grade ore. The gold is all free but so finely disseminated that the high grade ore which is a laminated or schistose quartz has merely a golden sheen. A great deal of this escaped amalgamation although enough was saved to pay well. These old tailings, which are rumored to have been worth 5 or 6 dollars a ton, soften

somewhat upon exposure to the weather so that the recovery by cyanide was very good.

The old cyanide plant had four iron tanks 5½ feet deep and 30 feet in diameter and supposedly the necessary other tanks and apparatus. When the tailings were exhausted the mine was sold to the Colossus Mining Company, a London corporation, which proposed to put in an immense plant to treat the entire zone. This zone had previously been cross cut by two trenches somewhat over 20 feet deep, but it was never properly sampled, for although there are many fairly rich streaks, the general average value is only 40 to 50 cents a ton. The tanks of the old mill were made a part of the new big mill, so the original arrangement of this successful plant could not be learned and also no one could be found to give information about the successful treatment. There is now a Ledgerwood cableway for economical handling of excavated rock. This dumps the skips of rock upon the feeding platform of a very large gyratory crusher discharging into a trommel. The coarse rock from the trommel goes through a smaller gyratory crusher into the bin cotaining the finer rock. From this bin it is hoisted to a long, rotating cylinder dryer discharging to the first of a pair of Allis rolls working in series with necessary screens and elevators. The fine material from these rolls is divided among three ball mills of peculiar design. They have a vertical axis bearing arms which push a number of six inch iron balls around a horizontal runway.

There are at present no screens on these, and the product contains a good deal of troublesome dust or slimes, and some sand too coarse for successful cyaniding. From the ball mills a fine set of conveyors carry the dry material to any one of the leaching tanks. There are six tanks 5½ feet deep and 40 feet in diameter, and four tanks 5½ feet deep by 30 feet in diameter, all in the open air; and the necessary solution, gold and slump tanks. The mill is very badly designed since the rolls have scarcely capacity for 75 tons per day and the ball mills were so overworked that much coarse sand passed

through them. On the other hand, the crushers, elevators, etc., have a capacity fully four times as great. The mill has been used by the present management in making cyanide tests upon the rich ore remaining in the chimneys. Even when crushed very fine this fresh unaltered ore can be leached for a week without apparently giving up more than half its gold, thus this cyanide plant cannot be used for this ore.

At present the most productive cyanide plant in this State is the one at the Iola Mine, near Candor, Montgomery County. The ore, coming from a pretty sharply defined vein, is either a hard, glassy, white quartz with traces of unreplaced slate, carrying coarse gold in octahedral crystals; or soft sugary, white quartz generally richer but not showing visible gold. This "sugar quartz" has lately been running from $14.00 to $20.00 per ton. It is crushed in a dilapidated 20 stamp mill where the coarse gold and much of the fine gold is amalgamated as usual. The tailings are elevated and are run to the various settling tanks or "sand boats," 3 feet wide at one end, 5 feet at the other, 12 feet long and 3½ feet deep, having at the small end a wooden lattice on the inner side of which a canvass curtain may be rolled up from the bottom. When the thin tailings run into this the sand settles out and the fine part or slimes flow into the slime tanks. As the sand accumulates the curtain is unrolled so that the overflow is just above the level of the top of the sand. The other two sand boats, just above the tanks, are plain boxes 6 feet by 3½ by 15 feet. One end is bored full of holes to let out the slimes. These are plugged as the level of the sand reaches them.

The wet sand from these boats is shovelled or wheeled into whichever of the sand tanks may be empty. This shovelling thoroughly breaks up any water tight layers of slime which may have formed when the mill was shut down for a short time, and the thin pulp remaining below the overflow has a chance to settle in a layer on top of the sand. It also supplies the needed oxygen to aid the cyanide in dissolving the gold. The sand tanks were made locally of yellow pine and

are 4 feet deep and 20 feet in diameter with the usual cocoa matting filter in the bottom. When filled to convenient height, they hold 40 tons of sand. A solution containing 1.4 pounds of potassium cyanide per ton of water is pumped upon this and drained off through the filter; this solution is kept circulating as rapidly as possible, keeping the sand always covered, for three or four days until the sand must be removed to make room for another batch. Then the solution is allowed to drain off, after which a little water is added to displace what solution remains in the damp sand. The sand is then washed out by a stream of water from a hose through an opening in the bottom of the tank into a trough or launder, to a settling pond where the sand settles out and the water collects to be pumped back again.

The slimes flow from the sand boats to one of the three agitation tanks 10 feet deep and 20 feet in diameter. Near the bottom of each of these is a slowly revolving paddle consisting of four well braced oak arms carrying pins. Some of the surplus water is drained off and a solution carrying 1 pound of potassium cyanide per ton of water (0.05%) is added. The agitation continues while the solution and slimes are drawn off at the bottom to a 4-inch centrifugal pump, thus thoroughly aerating and mixing it. This process continues until the tank is needed for more slimes. The solution is then pumped into one of the settling tanks 14x18 feet at a little lower level. Here the solid matter slowly settles out and the clear solution is drawn off. Sometimes the slimes are returned for a treatment with a second solution until they are finally sluiced out to waste. The solution from the sand tank, which now contains the gold, is passed directly to the zinc boxes; these have six compartments, 2x2x2 feet, with a side trough and a diaphragm for circulating the solution. This arrangement allows any one box to be emptied and cleaned while the solution circulates through the others.

From the zinc boxes the solution flows to the sump tank, 10x20 feet. Here more potassium cyanide is added to replace what has been consumed until the solution reaches the right

strength. This sump tank thus serves for a solution tank, from which the solution is raised by a small centrifugal pump to the sand leaching tanks. Most other mills have a small extra tank at the highest level in which the solution is made up and from which it flows by gravity to the sand tanks.

The clear solution from the slime settling tank is stored in the tank 24x8 feet. From this it flows through an eight compartment zinc box like the other one and to the sump and weak solution tank.

In the zinc boxes zinc from a mass of fine zinc shavings enters the solution in place of the gold which is precipitated as a black coating upon the zinc. Each month the zinc in the boxes is sifted and the fine stuff saved, and the coarse stuff returned to the box. The deficiency of coarse zinc in the first box is made up by taking some of it from the second, which is in turn filled from the third and so on. All the fresh zinc required is added to the last compartment, and, since much of the gold sticks to the zinc until it is all dissolved, most of the gold slimes are recovered from the first compartment where precipitation is also most active, as the solution passing through it contains the largest percentage of gold.

The gold slimes, or finely divided gold, containing small scraps of zinc, is melted in a graphite crucible to which a little nitre is added to oxidize the zinc and cause it to unite with the borax used as a flux. The melted gold is cast into bricks and sent to the mint.

All the tanks are in the open air. The pipes are wrapped to prevent freezing, and there is no trouble except that heavy rains increase the amount of solution which must be wasted and so cause a greater loss of potassium cyanide. The pumps, and the engine for driving them and the agitators, are housed in. In the same building is the room containing the zinc boxes and furnace for melting the bullion. About 4-10 of a pound of potassium cyanide is consumed per ton of ore. In the ore are no copper minerals or similar substances to consume cyanide.

Eight pounds of lime are added to each ton of tailings on its way to the cyanide plant. This is to cause the slimes to settle more readily and neutralize any acid which may be formed from the pyrites in the ore, and which would otherwise consume cyanide. The chief loss of cyanide is, therefore, in the solution that is wasted with the wet slimes.

There is required one solution man at $1.50 a day for each shift. If one-half of the steam used at the mill is charged to the cyanide part, the total cost exclusive of interest and depreciation is $0.90 per ton. The tailings from the cyanide plant contain about $1.00 per ton of gold. Since the sands from the mill had been carrying $4.86 per ton, there is a handsome profit in the cyanide plant—about $2.90 per ton treated. The cost of the plant was from $10,000 to $12,000. The loss in the tailings could be reduced by a longer treatment of the sands and the intention is to add two more sand leaching tanks for this purpose.*

At the Montgomery mine, which adjoins the Iola, there is another cyanide plant for treating tailings from a 10 stamp mill. All of the tanks are square. The stream of tailings is first separated into slimes and sands in a pointed box. Near the bottom of this box is a pipe out of which the coarse sand, which settles most rapidly, flows to the settling tanks, over the sand tank, while the slimes overflow at the top opposite the inlet. The slimes are not treated and the sand treatment does not differ essentially from that at Iola. The mine was shut down at the time of the visit so no data as to the cyanide treatment could be obtained. From the relatively greater tank capacity, the sand probably receives a longer treatment. The solution tanks and zinc boxes are inside the mill.

There is a new cyanide mill at the Southern Homestake Mine, 13 miles south of Thomasville, near Cox, Randolph County.

*NOTE—The data as to the cyanide treatment was mostly obtained from Mr. W. T. Sawyer, former superintendent, checked as far as possible by Mr. Jones, the present superintendent.

The ore passes over a grizzly, the oversize from which goes through a Blake crusher, and, with the fines from the grizzly, are elevated to a trommel screen above a small storage bin. The oversize from this trommel passes through a pair of corrugated rolls, then back to the same trommel, and so on, until it is all reduced to sand. The corrugated rolls chattered badly on account of the coarse feed; and the soft clayey ore tends to stick them so it will probably be better to use instead a number of smooth rolls in series.

The fine dry ore is taken by a belt conveyor to one of the three sheet iron leaching tanks, 6 feet deep and 30 feet in diameter. It was assumed that the solution would percolate through the 5½ feet of dry crushed ore, even though the slimes were not removed; but in the actual tests the tanks were filled only half full. Below the level of these leaching tanks are zinc boxes and sump tanks; the three solution tanks are on a trestle outside the main building, covering the leaching tanks.

The property was purchased without adequate sampling and the work was abandoned after treating 150 tons and finding that the ore averaged only $2.00 a ton. No data as to time of treatment, strength of solution, etc., was obtained. The recovery on the three tanks tried was 70, 80 and 83 per cent respectively. The ore is decomposed rock, occurring in wide zones and carrying a great deal of clay. No data was obtained as to the capacity of the mill.

MINING DETAILS (SELF-DUMPING SKIPS, ETC.)

Many of the mines in North Carolina are based upon more or less flat veins and since most of the ore is hoisted in buckets, it is customary to sink vertical shafts. When the mines become deep, this requires expensive cross-cuts to reach the vein; hence there are many vertical shafts which are turned upon reaching the vein and not adapted to the use of a cage or an ordinary style skip. Mr. Geo. E. Price has overcome this difficulty at the Rudisill Mine, at Charlotte, Mecklenburg County, by modifying the ordinary skip, and

adapting it to his special needs. The shaft is vertical for 200 feet and then inclines at an angle of 35° from the horizontal for 150 feet more. The skip is the ordinary iron skip, except that the wheels are a little larger than usual to reduce friction on the incline and all have narrow treads. In the vertical part these wheels run between two vertical guide timbers. The rope is not over the center of the shaft but toward the dumping side so that when the skip reaches the top the front wheels run down the forward curve of the track until they strike the top. Then the rear wheels swing to the rear in the arc of a circle. Just before they reach the top of this arc the nose of the skip strikes a roller which raises the front wheels sufficiently to bring them to a bearing against the front vertical guide so that in case of overwinding the skip rises at the dumping angle and rock cannot be dumped down the shaft. In this way the skip need wait at the top of the shaft only long enough for the ore to slide out of it, which is but a small fraction of a minute.

The ore is dumped from the car on to a platform about 3 feet below the level of the rails and the skip is stopped with its top about level with this platform and nearly filling the opening in it. If the output of the mine was a little greater, Mr. Price would replace the platform by a small bin, into which the cars could be dumped as they reach the station and from which the ore could be rapidly run into a skip through a chute. But since the man that would be required to operate the gate has ample time to shovel all the ore into the skip, there would be no labor saving in the bins and no justification for the expense. For even a small mine this skip saves the labor of a top man.

In the ordinary vertical shaft the bales of the skips are fitted with shoes and there are no wheels on the skip which is unlatched and dumped at the top by rollers striking suitable curved guides. Such a skip has the advantage of needing only one set of guides and no wheels, but it cannot be operated around a curve.

The labor of the top man is also avoided by a self-dumping bucket observed at the Haile Gold Mine, South Carolina. This is an ordinary bucket fitted with guide wheels. The back wheels are caught by a latch at the dumping place and turns over when the rope is slacked off. Then the bucket is raised, the latch is withdrawn by the engineer and the bucket lowered.

CHAPEL HILL FERNS AND THEIR ALLIES

The accompanying list of ferns of this region, including an area of about two miles radius around Chapel Hill, has been in course of preparation for several years, and is now, in all probability, very nearly complete. The topography of Chapel Hill is quite favorable to fern growth, and the number found here is as large as could be expected in regions free from limestone.

In his "Catalogue of the Indigenous and Naturalized Plants of the State," by Dr. M. A. Curtis*, there are given thirty-eight true ferns and eleven fern allies for the State of North Carolina. Of the species mentioned by him, eighteen ferns and four fern allies occur in Chapel Hill, while two of the ferns in the following list are not recorded by Curtis for this State. These are Botrychium obliquum var. dissectum, and Dryopteris Goldieana var. celsa.

The list of our ferns is as follows:

BOTRYCHIUM OBLIQUUM MUHL. (B. ternatum Chapm.). Ternate Grape fern. Not uncommon in damp, shaded places.

BOTRYCHIUM OBLIQUUM VAR. DISSECTUM. Dissected Grape-fern. Found only once in a low place near Judge's spring.

BOTRYCHIUM VIRGINIANUM (L.) Sw. Virginia Grape-fern. Rather more common than B. obliquum and occurring in similar situations.

OSMUNDA SPECTABILIS WILLD. Royal Fern. (Distinct from O. regalis L. of Europe). Common along small streams.

OSMUNDA CINNAMOMEA L. Cinnamon Fern. Common along small streams and in low, damp places.

POLYPODIUM VULGARE L. Common Polypody. Very rare. Known only to occur at Upper Laurel Hill where it covers the face of a high rock, looking north.

*Geological and Natural History Survey of North Carolina, Part III, Raleigh, 1867.

POLYPODIUM POLYPODIOIDES (L.) A. S. Hitchcock. (P. incanum Sw.). Resurrection Fern. On shaded trunks of elms and occasionally on rocks; not rare.

PTERIDIUM AQUILINUM (L.) Kuhn. (Pteris aquilina L.) Bracken or Brake. In dry woods and sometimes in fields. Common.

ADIANTUM PEDATUM L. Maiden-hair Fern. Found in three situations; in rich places near the foot of hills looking north.

CHEILANTHES LANOSA (Michx.) Watt. (C. vestita Sw.) Hairy Lip-fern. Found only on one rock on northern side of Morgan's Creek near Scott's Hole.

ASPLENIUM PLATYNEURON (L.) Oaks. (A. ebeneum Ait.) Ebony Spleenwort. Common in woods and in niches of stone walls.

ASPLENIUM ACROSTICHOIDES Sw. Silvery Spleenwort. Found only in two clumps near the base of Lone Pine Hill looking north.

ASPLENIUM FELIX-FOEMINA (L.) Bernh. Lady Fern. Very common along streams and in damp places.

WOODWARDIA AREOLATA (L.) Moore. Chain Fern. Found only in a marshy spot about one-half mile south-west of the University.

ONOCLEA SENSIBILIS L. Sensitive Fern. Scattered here and there in wet places.

DRYOPTERIS ACROSTICHOIDES (Michx.) Kuntze. Christmas Fern. Abundant along streams and on northern slopes of hills.

DRYOPTERIS THELYTERIS (L.) A. Gray. Marsh Shield-fern. Found only in marsh north of Lone Pine Hill.

DRYOPTERIS GOLDIEANA (Hook.) A. Gray. var. celsa. This fern was recently found near the northern foot of Lone Pine Hill. About eight specimens occurred scattered over a radius of seventy-five yards. It has not before been recorded for this State. It was described from Dismal Swamp by Palmer in the Proceedings of the Biological Society of Washington, Volume XIII, page 65, 1899. Specimens have since

been found in New York and New Jersey. For this information I am indebted to Professor L. M. Underwood and Mr. R. C. Benedict of New York. Dr. Underwood considers the fern a hybrid between D. goldieana and D. marginalis. It is not described in any of our manuals.

PHEGOPTERIS HEXAGONOPTERA (Michx.) Fée. Beech Fern. Not uncommon in flat places along small streams.

WOODSIA OBTUSA (Spreng) Torr. Found only on a few stone walls in town.

The fern allies found here are as follows:

EQUISETUM HYEMALE L. Scouring-rush. Found by Dr. H. V. Wilson along Morgan's Creek. Occurring also along the Oxford road near Durham.

LYCOPODIUM ALOPECUROIDES L. Club-moss. Growing only in an open wet place near the spot where Woodwardia was found.

LYCOPODIUM COMPLANATUM L. Christmas-green. Found by me only near upper Laurel Hill. Reported from a few places by others.

SELAGINELLA APUS L. Spring. Rather common among moss in wet places.

W. C. Coker

SALISBURY'S PHYSIOGRAPHY.*

COLLIER COBB.

Teachers of physiography in colleges will welcome this book, not only because it is the first of its kind of college grade, but also for the large amount of fresh material that it contains and its admirable arrangement, the author being at the same time a skilled investigator and a successful teacher.

"In the preparation of the text," he tells us, "the effort has been to shape it, when practicable, so as to lead the student into the subject under discussion, rather than to tell him the conclusions which have been reached by those who have made the subject their special study." The author holds persistently to that idea of physiography which regards the origin of land forms as its chief problem. This is not the English idea of physiography, but it is preëminently the American idea. It is the geography which Mackinder of Oxford defined as the study of the present in the light of the past, as distinguished from geology, which is the study of the past in the light of the present.

If the high school teacher is disappointed that small space has been given to certain topics that he has associated with text-books of physical geography, such as minerals and rocks, and plants and animals, let him remember that in colleges, where the author purposes the book shall be used, special courses in these related subjects are given in associated departments. In fact a strong point of the book is that,

*PHYSIOGRAPHY. By Prof. R. D. Salisbury, University of Chicago. 8 vo. 770 pp. American Science Series—Advanced Course. $3.50. New York: Henry Holt and Company.

with the exception of a few references to physiographic effects on human life, scattered through its pages, it presents physiography as a science associating causes and effects clearly and forcibly, thus avoiding the mistake made by many who exalt physiographic control at the expense of a science deeply interesting for its own sake.

Any study of the origin of land forms involves the study of both air and water, since air is the medium through which solar energy is applied to the earth, and water is the greatest agent in producing effects on the earth's surface. Though the greater part of the book is given to land forms, still 273 pages remain for the treatment of the atmosphere, the ocean, and the earth's solar relations. The treatment is essentially dynamic, and the movement in the direction of the explanation of the origin of the land forms of the earth. The reader is led to see these forms in the process of becoming what they are, and to anticipate the time when they shall give way to other forms. The surface of the earth becomes a stage where physical forces play their part, now in one role, now in another, until the land above the sea is reduced to base level, or rejuvenated by elevation to begin a similar sequence of events, to enter upon a new cycle.

The first chapter of the book introduces the reader to the chief relief forms of the earth's crust and the materials out of which they are made. This general survey places the problem of the land forms well before the student, and prepares him for the consideration of the agents that have shaped them. Then follow chapters explaining and discussing the work of the atmosphere, of ground water, running water, snow and ice, of waves and currents in the construction of shore forms, of vulcanism, and the effects of crustal movement, or diastrophism. For the first time does the work of the atmosphere receive anything like adequate treatment in a text-book of physiography. These chapters are followed by a very excellent generalization and summary of the origin and distribution of land forms clinching in the minds of the students the facts that have been brought out and driven home by varied investigations.

The part played by the atmosphere in the evolution of surface forms has received a treatment comparable in detail to that presented by special text-books of meteorology. The energy derived from the sun is followed through a series of transformations, in the chapters on atmospheric pressure, the movement of air currents, and the transportation of water vapor to its final precipitation upon the earth. The various elements of climate and the zones of climate receive due attention. In these chapters the composition of the atmosphere, the air in its life relations, the distribution of temperatures over the earth, and the philosophy of the movements of the air are treated in an interesting and original manner. The chapter on the storms of the United States is especially detailed and illustrated by a complete series of isothermal charts and weather maps. Following the chapters on the atmosphere, six chapters covering fifty pages are given to the discussion of the principal facts of oceanography.

The book contains more than seven hundred illustrations, forty-three of which are sections of topographic maps; and of the others more than half are half-tones from excellent photographs. This can by no means replace field-work but serves rather to invite to work out of doors; for the author says in his preface: "Another phase of work which should not be neglected is work out of doors. This must form a part of the work of every strong course in this subject. Directions for local field-work cannot be outlined profitably in a text-book, for the work must be shaped with reference to the specific locality where the subject is studied. Both field-work and map work should have for their aim the application of the principles studied, in such a way as to make the subject vital. The aim of every laboratory exercise carried out in connection with this subject should be the same, and any laboratory work which does not either illustrate and enforce principles, or lead to them, is not worth development. The student who cannot apply what he has learned in the class-room to to his out-of-door surroundings, has not secured the maximum good from his study of the subject."

At the end of each chapter is a well selected list of topographic maps, with suggestions as to their use in relation to the text, and a list of classified and paged references for supplementary reading. These references, even without the text, would be a most valuable aid to the advanced student or teacher, as they have been gathered through long experience in the class room. The author's style is pleasing and not too technical, and the average public school teacher will find the book an invaluable aid in the teaching of physical geography, though it was written primarily for the college student.